Patent Office
Canberra

I, SMILJA DRAGOSAVLJEVIC, TEAM LEADER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Complete specification in connection with Application No. 2003203512 for a patent by MICHAEL TERRENCE PATTERSON as filed on 01 April 2003.

WITNESS my hand this
Fourth day of September 2003

S. Dragosavljevic

SMILJA DRAGOSAVLJEVIC
TEAM LEADER EXAMINATION
SUPPORT AND SALES

AUSTRALIA

The Patents Act 1990

COMPLETE SPECIFICATION

STANDARD PATENT

"THERMAL HYDRAULIC SOLAR TRACKING DEVICE"

The following statement is a full description of this invention, including the best method of performing it known to me.

The present invention relates to a solar tracking device.

It is an object of the present invention to provide a simple and rugged method of ensuring the optimum positioning of solar collector panels.

A further object is to reduce the cost of providing electrical energy using photovoltaic cells by maximizing the period of time during the day that the solar collector is pointed toward the sun. Most solar tracking devices created in the past have been either expensive to manufacture and / or unreliable, also many such devices require electrical energy to drive them. This energy is usually subtracted from the total energy provided by the solar collector. Few passive trackers have gone into production and those that have are not very efficient because they do not return to the east until the following day or will not operate successfully during overcast and windy conditions.

With these objects in view the present invention in a preferred aspect may provide a solar tracking device, which uses the volumetric expansion of a liquid as the motive source. The liquid used in the present invention has optimum expansion properties when heated and will maintain a useful rate of expansion over a wide temperature range. The liquid has a low freezing point and a high boiling point. The device does not require high temperatures to operate, merely a temperature range of approximately ten degrees Celsius thus permitting operation in extremes of climate.

To assist with the understanding of the invention, reference will be made to the accompanying drawings,

FIG.1 is an isometric view showing one embodiment of a two-axis tracker for a single photovoltaic panel.

FIG.2 and FIG. 3 are sectional views of the device depicted in FIG. 1 showing two positions of rotation

FIG.4 is a sectional view of the hydraulic ram shown in FIG. 1

FIG. 5 is an exploded view of the device shown in FIG. 1

FIG. 6 is an isometric view of a preferred embodiment of a tracker and support frame for a multiple array of photovoltaic panels.

FIG.7 is an exploded view of the device shown in FIG.6

FIG.8 is a partial sectional view of the device shown in FIG.6 showing two positions of rotation.

FIG.9 is a side view of the device depicted in FIG. 6 (frame removed) showing north south orientation method.

FIG.10 shows a sectional view of an alternative thermal hydraulic cylinder, using electric power to heat the liquid.

FIG.11 shows a view depicted in FIG. 9 with the addition of another thermal hydraulic cylinder shown in FIG. 4 to control north south orientation.

FIGS. 1- 5 show a single panel solar tracker in a preferred embodiment.

In FIG. 1 to FIG.5, there is shown an embodiment where support post 9 has slots cut into the upper end to accommodate rotational displacement of the axis pivot tube 12. Post 9 has location holes bored through to house the north- south axis pivot bolt 7 and north south axis-positioning clamp 8. Movement of pivot tube 12 is restricted by axis bolt 7 so that it pivots in the north south direction only. Right-angled axis pin 30 and spring retainer tube 31 are fixed to axis tube 12. Axis tube 12 is pierced to rotatingly mount the top end of clamp pin 14. Both ends of tube 12 are threaded for shoulder bolts 11. Lateral support brackets 5

and 6 are pivotally attached to tube 12 by bolts 11 and are held parallel by rod 10. Clamp plates 18 fix solar panel 1 to brackets 5 and 6. Locating holes provided in the western end of brackets 5 and 6 pivotally retain expansion tube and hydraulic cylinder assembly 2 and 3. The hydraulic cylinder 3 is comprised of an outer pressure tight cylinder, a linear actuator ram 4, an adjustable gland 15, a damper plate 16 and sealing "0" rings 17. A ferrule fixed to the outermost end of ram 4 is rotatingly mounted on right-angled pin 30.

The operation of the afore described embodiment commences when the sun begins to rise above the eastern horizon and the ambient air temperature increases; the liquid contained within expansion tube 2 and cylinder 3 also begins to expand. The liquid contained therein expands at a much greater rate than the surrounding container and a pressure is created which impinges on the cross sectional area of the ram 4 thus displacing it outward proportionally to the volumetric expansion of the liquid. The liquid used in the device has a volumetric expansion rate of approximately 0.085 cubic centimetres per degree Celsius increase; therefore 1 litre of liquid will expand to 1008.5 cc when raised in temperature by 10 degrees Celsius. Liquid is considered to be virtually incompressible therefore the potential pressure created by this expansion is extremely high and can be considered limited only by the strength of the container which holds it. In the afore described embodiment this pressure is used to force ram 4 outward with a limiting factor of the enclosing structure and "O" rings 17. The embodiment afore described is designed to rotate a P.V. (photovoltaic) panel of approximately one square metre and contains a volume of liquid sufficient to displace an actuator ram of 12 mm dia. (1.13square cm. cross sectional area) with a rise in temperature of 10 degrees Celsius, by 75 mm. and a

pressure which is determined by the physical housing structure and sealing rings. The sealing rings are conventional "O" rings, which are nominally considered to have a safe operating pressure of 10.3 MPa. This pressure can provide a rotational force of 119 kg. which is more than needed to rotate the panel. The excess force provided can be used to dynamically control the positioning of the panel under high wind loads by transposing the externally applied forces to the internal structure of tube 2 and cylinder 3 and elastically deforming said structure thus maintaining an equilibrium of forces during the day. This system has been tested and proven to maintain the face of a P.V. panel to within 10 degrees of perfect orientation, which is 98.5% of best possible positioning.

Different locations require different volumes of liquid and / or a liquid that has a higher or lower expansion rate than the embodiment afore described; this is easily compensated for by adjustment of the threaded gland 15. and / or using an expansion liquid that has characteristics better suited to the climatic conditions of the installation site. Ambient temperatures usually increase at a steady rate during a normal climatic day and reach a maximum at about an hour after midday. When the increase in air temperature has rotated the P.V. panel to the horizontal position the expansion tube 2 is progressively exposed to solar radiation where the liquid contained therein continues to expand pushing the panel gradually toward the west. The liquid contained in tube 2 and cylinder 3 cools overnight permitting spring 13 to return solar panel 1 to the eastern most position. FIG. 4 shows a cross sectional view of hydraulic cylinder 3. Damper plate 16 is shown as a 3-piece assembly being composed of two outer plates of rigid material sandwiching a layer of resilient material that separates chambers

21 and 22 compelling excess fluid to flow to and fro via channel 20 bored into ram 4. This arrangement produces a dampening effect when the solar panel is exposed to high wind velocities.

FIGS. 6-FIGS. 9 show another embodiment according to the invention were a multiplicity of solar panels can be rotated simultaneously using the same basic expansion tube and hydraulic cylinder assembly as previously described. In this embodiment expansion tube 2 is located in a gap between two rows of solar panels 1, shown as phantom lines in FIG.6 and partly shaded by frame 14. A ferrule fixed to the outermost end of ram 4 is rotatably mounted to north south axis bracket 24 by clevis 8 and pin 32. Circular plate 23 fixed to pole 9 has a cam shaped slot and a central hole pierced through it. Bracket 24 is rotatably pinned to plate 23 by axis bolt 7 and clevis 8 passes through the slot in bracket 24 and cam slot in plate 23. FIG. 9 shows that when bracket 24 and attached assembly is manually rotated to compensate for seasonal conditions, clevis 8 is moved by the curved surface of the cam shaped slot in plate 23 impinging on it. Clevis 8 moves closer to the cylinder 3 and attached ram 4 is moved further into said cylinder 3. This procedure automatically compensates for the reduced volume of liquid that is caused by seasonal cooling.

FIG. 8 shows that the principal of operation of the embodiment shown in FIGS. 6-9 is similar to that shown in the embodiment described by FIGS.1-5

FIG.11 shows a method of positioning the PV panel to increase the potential output of the said panel through the application of a hydraulic cylinder as described by FIG. 4. The cylinder 36 contains a liquid that is calculated to provide an additional expansion volume so that no displacement of the ram will

occur during the mid winter maximum temperature but will provide maximum expanded volume during the summer maximum daytime temperature.

FIG. 10 shows an alternative method of heating and expanding the liquid contained in hydraulic cylinder 3 where an electric current is provided by battery 26 through a circuit containing a rheostat 28, a cam operated micro switch 27 and heating element 25. The power required to rotate the PV panels is very low and for the operation of a one square metre panel, is less than one watt when cylinder 3 is encased with adequate thermal insulation material 37.

FIG. 11 shows an addition of a thermal hydraulic cylinder assembly that is used to maintain north south orientation throughout the year. The cylinder is completely filled with the said liquid and the volume contained within the cylinder is calculated so that no movement of the ram 4 will occur during the expected highest midwinter temperature but will protrude to the maximum extent during the highest mid summer temperature.

While the invention has been described with respect to certain specific embodiments, it will be appreciated that many modifications and changes may be made by those skilled in the art without departing from the spirit and scope of the invention. It is intended, therefore, by the appended claims to cover all such modifications and changes as fall within the true spirit of the invention.

CLAIMS

1. A solar tracking device where a single or multiplicity of photovoltaic panels are rotated so that the optimum surface area of said panels is exposed to available solar radiation by the application of a single thermal hydraulic device primarily heated by convection from ambient air temperature where a high boiling point liquid contained within an expansion tube, hydraulic cylinder assembly, expands volumetrically, displacing an actuator ram by hydraulic pressure, providing the principal motive force of rotation.

2. The device of claim 1 wherein said liquid is a hydrocarbon, or carbohydrate found in nature or artificially derived, that has the characteristics of high thermal expansion rate, is a good lubricant, is readily available and is relatively inexpensive.

3.the device of claim 1 wherein the liquid remains in a liquid state throughout the full operational parameters of the device.

4. The device of claim 1 where the expansion tube is coated on the surface exposed to solar radiation with a material that readily absorbs radiant heat.

5. The device of claim 1 where the surface of the expansion tube and the hydraulic cylinder, not exposed to solar radiation, are coated or covered by a thermal insulation material.

6. The device of claim 1 where a spring is used to return the photovoltaic panels to the eastern most position as the said liquid cools over night.

7. The device of claim 1 where an imbalance of the said photovoltaic panels and attached frame favouring the eastern side causes gravity

to return the said panels to face the eastern most position as the liquid cools overnight.

8. The device of claim 1 where a damper built into the said hydraulic cylinder controls excessive movement of the said panels during high wind conditions.

9. The device of claim 1 where a windshield is used to prevent excessive air convection currents from reducing the temperature of the encapsulated liquid quicker than is desirable.

10. The device of claim 1 where the liquid is primarily heated by ambient air temperature but is also electrically heated to provide additional expansion of the liquid at a predetermined rate and controlled by appropriate electronic circuitry.

11. The device of claim 10 where the hydraulic cylinder is thermally insulated so that a minimum of electrical energy is required to provide the heat for expansion of rhe said liquid.

12. The device of claim 1 where the said thermal hydraulic device is used to rotate a photoelectric panel around a fixed north south axis and two axis support brackets are mounted on a pair of rails so that a multiplicity of PV panels are arranged side by side to form a linear array.

13. The device of claim 12 where a single thermal hydraulic device and PV panel assembly acts as a master controller for one or a number of adjacent panels linked by push-pull rods or cable connections in a linear array.

14. The device of claim 1 where the addition of a thermal hydraulic cylinder assembly is used to control the north south orientation of said tracker

FIG.1

PHOTOVOLTAIC MODULE SHOWN
ROTATED 50 DEG. EAST AND 30 DEG. NORTH
(SOUTHERN HEMISPHERE)

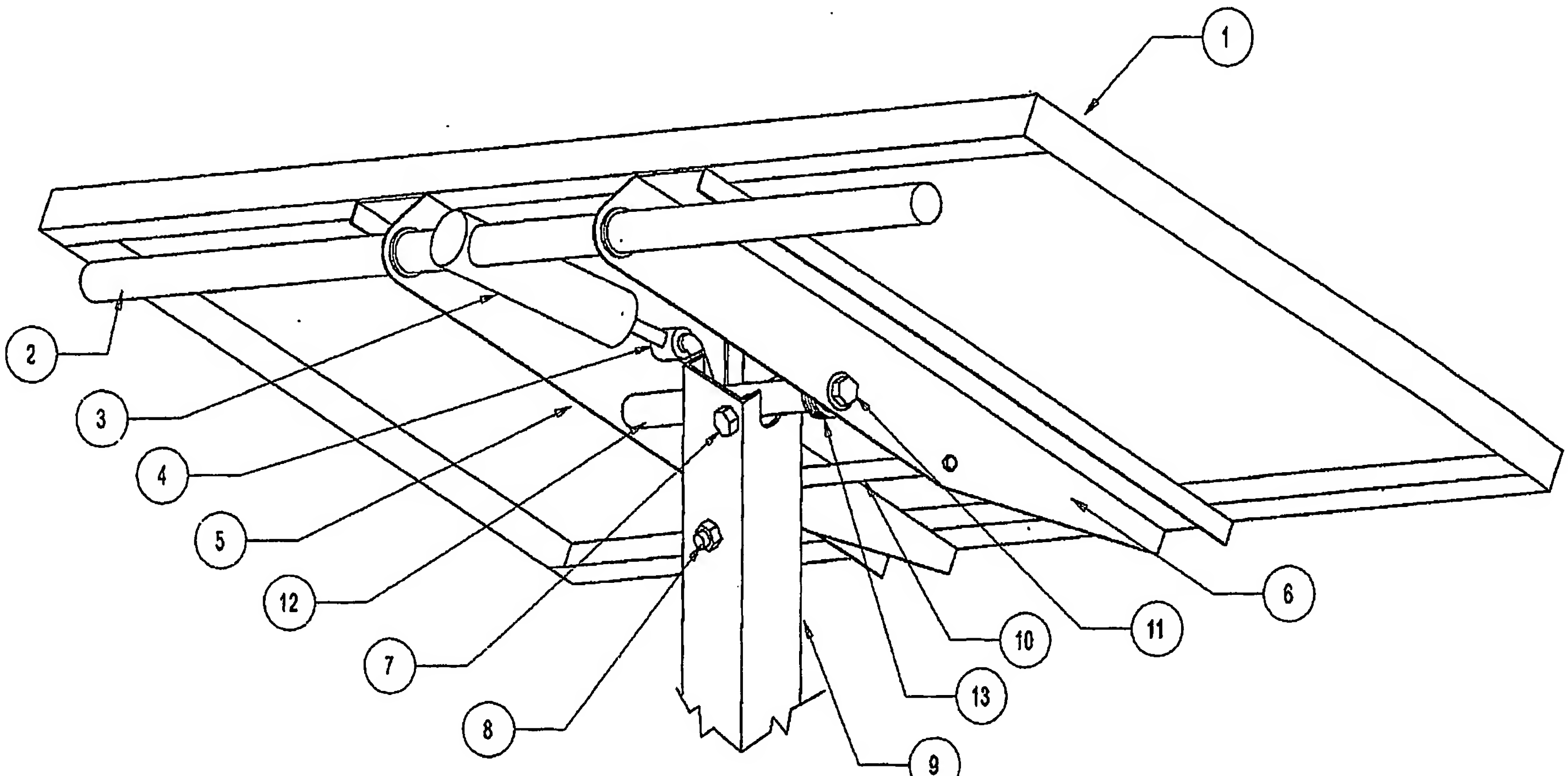

FIG.2

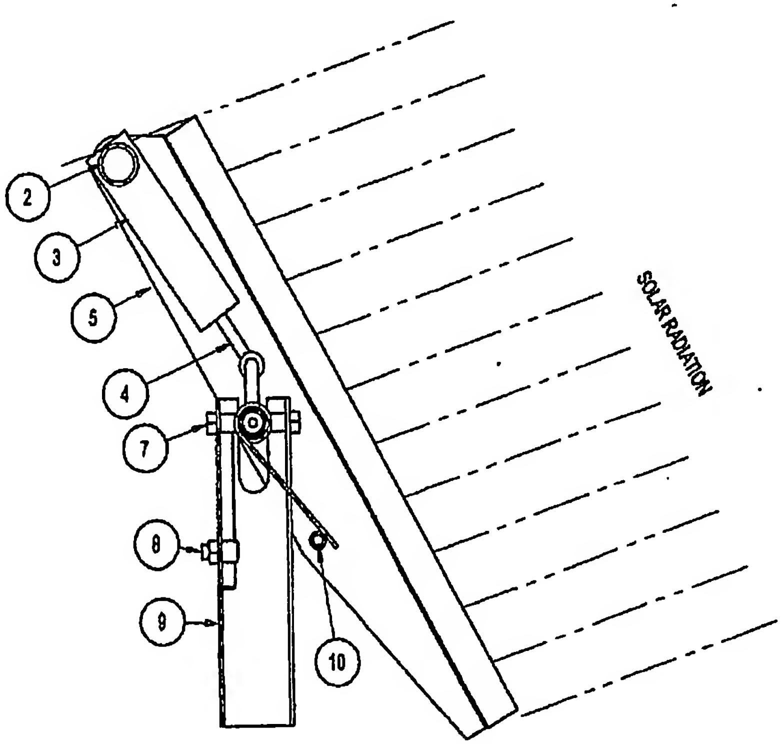

FIG.3